Review Article

The learning curve of posterior retroperitoneoscopic adrenalectomy: a review of literature

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Background and Objective: Posterior retroperitoneoscopic adrenalectomy has become an increasingly popular approach for removal of the adrenal gland. When compared to the transabdominal approach, it has several advantages including shorter operative time, less blood loss, less postoperative pain, faster recovery, improved cost-effectiveness, and abolished risk of trocar site herniation due to the direct approach to the adrenal gland. However, many surgeons still prefer the transabdominal approach, which is possibly a result of the uncommon anatomical view, limited working space and estimated longer learning curve of the retroperitoneal approach. The primary objective of this review was to evaluate the learning curve for posterior retroperitoneoscopic adrenalectomy and to propose a strategy for surgeons starting to learn this technique.

Methods: A literature search of the MEDLINE database was conducted in December 2021 using the following search items: "adrenalectomy", "retroperitoneoscopic" and "learning curve". Studies that included the learning curve or operative time for posterior retroperitoneoscopic adrenalectomy were selected. Studies in which the learning curve for lateral retroperitoneoscopic adrenalectomy was investigated, consisted of less than 30 procedures or were non-English were excluded from this review.

Key Content and Findings: The learning curve of posterior retroperitoneoscopic adrenalectomy is estimated to be around 20–40 procedures for experienced laparoscopic surgeons. The initial operative time and subsequent learning curve is much shorter after visiting and proctoring by an expert, and continued proctoring, optionally by telementoring. Furthermore, adequate patient selection can help surgeons learning the posterior retroperitoneoscopic approach to select the ideal patient who is most likely to benefit from this approach during their learning phase.

Conclusions: The posterior retroperitoneoscopic adrenalectomy has a short learning curve for experienced laparoscopic surgeons, when stepwise implementation is performed. Currently, there are several experts in this technique worldwide that can aid in successful implementation.

Keywords: Adrenalectomy; learning curve; retroperitoneoscopic; telementoring; operative time

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Introduction

After the introduction in 1992, minimally invasive adrenalectomy has become the gold standard for the removal of tumors of the adrenal gland (1). When compared to open surgery, minimally invasive adrenalectomy has several advantages, including less blood loss, shorter hospital stay, fewer complications and less postoperative pain (2,3). The most frequently used approach is the transabdominal lateral adrenalectomy (TLA), which offers good exposure and has easy identifiable anatomical landmarks. However, as

Table 1 Search strategy

(((adrenalectomy) AND (retroperitoneoscopic)) OR (retroperitoneal)) AND (learning curve), "((((""adrenalectomy""[MeSH Terms] OR ""adrenalectomy""[All Fields] OR ""adrenalectomies""[All Fields]) AND (""retroperitoneoscopic""[All Fields] OR ""retroperitoneoscopically""[All Fields])) OR (""retroperitonal""[All Fields] OR ""retroperitoneal space""[MeSH Terms] OR (""retroperitoneal""[All Fields] AND ""space""[All Fields]) OR ""retroperitoneal space""[All Fields] OR ""retroperitoneal""[All Fields] OR ""retroperitoneally""[All Fields])) AND (""learning curve""[MeSH Terms] OR (""learning""[All Fields] AND ""curve""[All Fields]) OR ""learning curve""[All Fields])"

the adrenal gland is located retroperitoneally, the posterior retroperitoneoscopic adrenalectomy (PRA) offers a more direct route to the adrenal gland and less chance of injury to intraperitoneal organs. This technique was introduced in 1994 (4), after which it was modified by Walz (5) and it has gained more popularity since. Walz and his colleagues introduced several preoperative selection criteria, such as body mass index (BMI) of <35 kg/m^2, tumor size ≤7 cm, and low suspicion of malignancy. In a randomized controlled trial by Barczyński *et al.*, several advantages were seen for PRA over TLA, including shorter operative time, less blood loss, less postoperative pain, faster recovery, improved cost-effectiveness, and abolished risk of trocar site herniation due to the direct approach to the adrenal gland avoiding intra-abdominal dissection and manipulation (6). Especially in bilateral cases, PRA has significant advantages regarding blood loss and operative time, since there is no need to reposition the patient (7). However, due to the limited working space, the uncommon anatomical view and a paucity of anatomical landmarks, this approach seems more difficult to learn. Hence, there have been several studies in which the learning curve of this technique has been investigated. During the implementation of a new surgical technique, two distinct paths of learning can be distinguished: the invention phase and the introduction phase (8). In the invention phase, in which a completely new technique is being developed, the learning curve is longer. In the introduction phase, in which a newly developed technique is introduced to another clinic with visiting and proctoring by an expert, the learning curve is usually much shorter. In this review the learning curve of PRA is evaluated. Furthermore, we propose a strategy for surgeons starting to learn this technique. We present the following article in accordance with the Narrative Review reporting checklist (available at https://ls.amegroups.com/article/view/10.21037/ls-22-20/rc).

Methods

Search strategy

A literature search of the MEDLINE database was conducted in December 2021. The following search items were used: "adrenalectomy", "retroperitoneoscopic" and "learning curve". Boolean operators of "AND" and "OR" were used with the appropriate synonyms to extend the search (*Table 1*). Furthermore, a manual screening of the bibliographies of the included studies was performed to identify additional studies.

Selection criteria and data extraction

Peer-reviewed, original studies in English were screened for title and abstract, subsequently full-text screening was performed for the selected studies. If the learning curve or operative time for PRA was described in the study, it was included for analysis. Studies in which the learning curve for lateral retroperitoneoscopic adrenalectomy was investigated were excluded from this review, since this is a different surgical approach which is less frequently used and described in literature. Also, studies in which less than 30 procedures were described were excluded, since there is a reasonable probability that the learning curve was not yet fully completed. After full text analysis, a narrative synthesis of the available literature was performed.

Discussion

Search results

In total, we found 200 articles using the search query. After screening the abstracts and subsequently the full texts, we included nine studies in this review in which the operative time and learning curve for PRA were specifically

Table 2 Main characteristics of included studies

First author and date	Total adrenalectomies (n)	Median operative time (min)	Number operations: operative time (min)	Other remarks
Walz, 2006 (9)	560	55	1–112: 106±46	–
			113–224: 70	
			225–336: 52	
			337–448: 42	
			449–560: 40±15	
Barczyński, 2007 (8)	Invention phase: 50	Invention: 117±42	–	20–25 procedures to complete learning curve (operative time <90 min)
	Introduction phase: 50	Introduction: 82±28		
Schreinemakers, 2010 (10)	112	100 (90–130)	1–17: 120±20	–
			18–35: 125	
			36–50: 105	
			51–74: 90	
			75–94: 90	
			>95: 70	
Kiriakopoulos 2011 (11)	30	90 (74–120)	1–20: 98 (80–165)	–
			21–30: 70 (60–110)	
Cabalag, 2015 (12)	50	71 (54–85)	>15 cases: 61 (50–75)	After 15 cases plateau phase in operative time
Van Uitert, 2017 (13)	113	62	1–20: 100	Regression coefficient 0 around 70 patients
			21–40: 83	
			41–60: 60	
Vrielink, 2018 (14)	181 (4 teams)	89 (29–265)	–	LC-CUSUM analysis: competency after 24, 29, 40 and 42 procedures
Kook, 2021 (15)	391	84±31	1–90: 84±26	More difficult cases included later
			91–200: 83±34	
			201–391: 84±32	
Rah, 2021 (16)	284	68±35	–	LC-CUSUM analysis: Surgeon A: 24 procedures; Surgeon B: 26 procedures

Variables are presented as mean ± standard deviation if normally distributed, otherwise as median (interquartile range). LC-CUSUM, Learning Curve Cumulative Sum.

investigated. We provided an overview of the results in *Table 2*.

Learning curve

In 2006, Walz *et al.* reported the outcomes of the first 560 patients after introduction of this surgical approach (9). In this study operative time decreased significantly from 106±46 minutes in the first 112 patients to 40±15 minutes for the last 112 patients. Eleven patients (2%) that required a conversion were excluded from the study. Factors resulting in longer operative time were male sex, pheochromocytoma, right-sided surgery and tumor size >3 cm. In this study the operative time of the invention phase of a new technique was described, and several modifications and improvements were made during the study period.

Barczyński *et al.* compared the perioperative outcomes of the first 50 patients that underwent PRA in the invention phase (group A) with 50 patients that underwent PRA in another hospital ten years later (introduction phase, group B) (8). The surgeons in group B were trained and supervised by the surgeons from group A and performed the slightly modified technique, which was improved by group A throughout the 10-year period before. Baseline characteristics were fairly similar between both groups, but group B included significantly larger non-functioning adenomas. There was a significant difference in conversions to open surgery (7 patients *vs.* 1 patient, respectively) between group A and B. Furthermore, operative time was significantly longer in group A compared to group B (117±41 *vs.* 83±35 minutes). Both groups had the steepest learning curve in the first 20–25 patients. Also in this study, male sex, pheochromocytoma and tumors >3 cm affected operative time. Schreinemakers *et al.* reported their initial experience with PRA of 112 patients (10). All procedures were performed or supervised by one surgeon. No information was given regarding training or supervision received prior to the introduction of the technique. Surgery time decreased significantly after the first 30 patients from 120 (100–140) to 90 (88–120) minutes. There was a further decrease in operative time to ±70 minutes for the last ten procedures. Kiriakopoulos *et al.* performed a matched case-control study in 60 patients, comparing PRA and TLA (11). This study showed a significant reduction in operative time when comparing the first 20 patients to the last 10 patients (98 *vs.* 70 minutes). Miller *et al.* reported their preparation for introduction of PRA (17). First, they visited an expert in PRA. Second, hands-on training and on-site proctoring were performed by a colleague familiar with PRA. Third, subsequent cases were observed by remote telementoring by an expert in PRA. During this period, also the operating team and anesthesiologists were briefed and educated. After this training period, the surgical outcomes of the first 50 patients were reported by Cabalag *et al.* (12). Operative time decreased with a mean of 4.2 min per case for the first 10 cases, and 2.3 min per case for the subsequent 5 cases. After this there was no further reduction in operative time with a median of 61 minutes. In our hospital we evaluated the learning curve for PRA after introduction of the technique in 2011 (13). All patients that underwent PRA were included in this study. One surgeon was trained extensively by visiting and proctoring of an expert in PRA. There was a significant decrease in median operative time between the first 20 patients compared to patients 21–40, and 41–60 from 100 to 83, and 60 minutes, respectively. Although the steepest learning curve occurred in the first 40 patients, the regression coefficient for operative time reached zero after 70 patients. Vrielink *et al.* performed a multicenter study to evaluate the learning curve in PRA in four surgical teams in three different countries (14). In this study the first 50 patients that received PRA were included in the analysis. The strategy for implementing PRA varied among the four teams. All surgeons watched videos of the procedure; three teams received hands-on training by an expert for seven to fourteen procedures. Two teams subsequently received proctoring for the next couple of procedures, (but) the exact number was not described. Completion of learning curve and competency were assessed by the "Learning Curve Cumulative Sum (LC-CUSUM)" analysis, which included operative time and conversions (18). An operative time of >130 minutes or a conversion were defined as an incompetent performance. The four surgical teams reached competency in PRA after 24, 29, 40 and 42 procedures. When comparing the four teams, they showed that visiting a proctor, followed by continued proctoring, and working in surgical teams of two dedicated surgeons accelerated the learning curve of PRA with a minimal need for conversions. Working with a dedicated surgical team is a very important factor influencing operative time in minimally invasive surgery (19,20). Kook *et al.* reported the outcomes of 391 patients who received PRA (15). These patients were divided in three subgroups based on time period (2009–2012 *vs.* 2013–2015 *vs.* 2016–2018). There was no decrease in operative time between the three subgroups (83.6 *vs.* 83.3 *vs.* 83.9 minutes), but they included more difficult cases later in the study. Rah *et al.* reported the results of 284 patients who received PRA by two surgeons (16). Using CUSUM-analysis the learning curve was 24 procedures for surgeon A and 26 procedures for surgeon B. No information was given regarding training or thresholds of the CUSUM-analysis.

In all studies the number of perioperative complications was low and no significant relation between learning curve and perioperative complications was shown. Possible explanations for this could be that the absolute number of complications in this type of surgery is generally low, so you need large patient numbers to show a difference. Furthermore, when getting more proficient in this technique, more challenging cases could be selected for PRA, which could subsequently increase the probability of complications, counteracting the effect of the learning process.

Surgeons in these studies already had previous experience in laparoscopic surgery and TLA before learning PRA.

Previous experience with the retroperitoneoscopic approach for other surgical indications, such as a partial nephrectomy, could probably expedite the learning curve even further due to higher familiarity with the anatomical view, however this was not described in the studies.

Lastly, the different pathologies were not completely homogeneously distributed between the studies. Different indications for surgery can pose different challenges during surgery. For instance, pheochromocytomas can result in more difficult surgery, due to the fact that they generally consist of highly vascularized and fragile tissues, requiring careful dissection. This could have influenced operating time and the learning process.

Telementoring

Telementoring can also play a role in learning the technique of PRA. Telementoring is a technique of telemedicine using interactive two-way video-audio communication between two surgeons, which involves an expert surgeon remotely observing and guiding a less experienced colleague in a surgical procedure. Treter *et al.* described the successful implementation of PRA in their hospital in two cases using telemonitoring (21). A systematic review by Erridge *et al.* that included 66 studies investigated the safety and efficacy of telementoring when compared to on-site mentoring (22). In this review the authors showed that in 58% of the included studies there was no difference in postoperative outcomes between both groups and one study found telementoring to be superior. In four (33%) studies telementoring was found to be inferior in some aspect, of which three reported longer operative time and in one study participants reported that they preferred on-site training. Although it is unlikely that telementoring will supersede on-site training completely, it can be a useful additional tool in continued proctoring for surgeons learning new techniques by expert mentors, since it negates the necessity to travel for the proctor.

Patient selection

Finally, adequate patient selection can aid the learning process. Classically, patients are eligible for PRA if they meet the following selection criteria: a BMI of <35 kg/m^2, tumor size ≤7 cm, and low suspicion of malignancy. Nevertheless, in several studies complex surgery is reported in male patients, right sided surgery, higher BMI, pheochromocytoma and several anatomical characteristics of the adrenal gland on preoperative imaging (23-26). To further optimize patient selection, we developed a preoperative nomogram to predict operative time in PRA (27). This nomogram was developed using best subsets regression analysis, and the four-variable model showed the best balance between predictive power and applicability. Variables included in the model were male sex, pheochromocytoma, BMI and perinephric fat. Preoperatively using the model can be of added value as a clinical support tool during the learning phase to select the ideal patient who is most likely to benefit from PRA.

Conclusions

After reviewing the available literature, the learning curve of PRA is around estimated to be around 20–40 procedures. To aid in successful implementation of this technique, we recommend several steps that should be taken. First of all, visiting an expert surgeon and observing several procedures accelerates the learning process and gives more insight in the surgical and non-surgical subtleties and pitfalls of the technique. Second, (hands-on) proctoring by an expert should be performed after implementation of the technique. Continued proctoring, optionally by telementoring, could be of additional value depending on the experience and skill level of the trainee. Currently, there are several experts in this technique worldwide that can aid in successful implementation. Finally, adequate patient selection can help surgeons learning PRA to select the ideal patient who is most likely to benefit from this approach during their learning phase.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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